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## PALEOGEOGRAPHIC MAPS OF NORTH AMERICA<sup>1</sup>

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At the Baltimore Meeting of the American Association for the Advancement of Science a number of paleogeographic maps of North America, representing the continent at intervals from Cambrian to Quaternary, were exhibited. They had been prepared in collaboration with some of the geologists who presented papers in the symposium on correlation, and to a certain extent they serve to illustrate the changing geologic conditions which form a factor in the problems of correlation. I have been requested to publish them in connection with the correlation papers in the *Journal of Geology*, and am glad to do so, although it is not practicable to present a discussion of the particular facts which have been considered in the construction of each individual map.

In general the lines of evidence have been considered somewhat in the following manner.

A certain period having been selected as that which should be mapped, the epicontinental strata pertaining to that time interval have been delineated. The phenomena of sedimentation and erosion have then been correlated, with a view to determining the sources of sediment and topographic conditions of land areas, and from these data the probable positions of lands have been more or less definitely inferred. Thus, certain areas within the continental margin are distinguished as land or sea, and these areas may be defined as separate bodies or connected according to inferences based upon isolated occurrences or upon later effects of erosion.

It is assumed that the great oceanic basins and such deeps as the Gulf of Mexico and the Caribbean have been permanent features of the earth's surface at least since some time in the pre-Cambrian. These deeps can thus be placed upon the map and their connection with the epicontinental seas may be tentatively established.

When the distribution of lands and waters is thus inferentially

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completed, we may infer further that the dominant features of oceanic circulation have obeyed the conditions of atmospheric circulation and of rotation of the sphere which now govern the great oceanic eddies. We may introduce in the Atlantic and Pacific the dominant drifts from east to west in equatorial regions with the resulting circulation northward along the east coast and southward along the west coast of the continent. A circulation of the oceanic waters in the epicontinental seas must result from the great oceanic drifts, and the direction of flow will be determined by the configuration of the lands and the depths of the seas.

From the geographic conditions thus developed inferences regarding the climate and the life habitats of the time may be drawn. If now we turn to the records of paleontology and compare the distribution of faunas and floras with the conditions of distribution which should result from the inferred physical phenomena, we may check the whole line of reasoning and by a readjustment draw a step nearer to the truth. This is the method which has been pursued in making the maps of North America that are published with the papers in this number and that will appear in connection with further papers of the series.

In a first essay of this kind (and I am not aware of any earlier attempt to combine the various lines of evidence in a similar manner) it is probable that important facts have been overlooked. The very broad scope of the discussion makes this probability almost a certainty, and it is not to be expected that the maps here presented should give a final or satisfactory solution of the problems. They are to be regarded as tentative and suggestive only.

On one point they have been particularly criticized, it being said that each individual map covers so long a period of time and such diverse conditions that they do not truly represent any special geographic phase of the continent. This criticism is valid, and one of the steps in the advancement of knowledge will be that of selecting narrower time limits and more precise correlations than have been attempted in these cases. We may undoubtedly make progress in this direction at the present time so that the fifteen maps which will accompany this series may be replaced by two or three times as many; but there is danger in carrying the refinements too far on the



basis of paleontologic correlation alone, since it is still difficult to distinguish between synchronous and homotaxial faunas or floras. It may be hoped that these paleogeographic studies will themselves assist us to a better understanding of the evolution of life conditions and thus lead to a solution of some of the problems of correlation with the aid of biologic evidence.

#### I. LOWER CAMBRIAN NORTH AMERICA

The map of lower Cambrian North America presented herewith conforms to the outline developed by Mr. Walcott in the course of his studies. East and west of the central land mass are relatively narrow sounds limited on the oceanic side by islands or land masses of indeterminate extent. The old land area of Appalachia is believed to have covered the region of the West Indian Islands, it being well established that a somewhat extensive land extended to the southeast of the Appalachian trough, and it being plausible that that land lay between the Atlantic deep on the northeast and the deeps of the Caribbean and Gulf of Mexico. In the adaptation of marine currents to oceanic and continental features, it is inferred that the return waters from the Arctic occupied the sounds along the inner continental margins. The distribution of these currents suggests that the habitat of the lower Cambrian fauna of the Appalachian trough on the east and the British Columbia-Nevada trough on the west was determined by the cool waters flowing southward. This view of dispersion of the faunas from the north is not shared by Mr. Walcott, who presents the alternative hypothesis of a connection of the faunas around the southern margin of the continent. The fauna of the Nevada basin appears to belong to warmer waters than that of British Columbia, inasmuch as it contains corals. The land areas of lower Cambrian time throughout the northern hemisphere appear to have been large. There is evidence in the character of the sediments and in glacial deposits in China that there were marked contrasts of climate.

#### 2. LATE MIDDLE AND UPPER CAMBRIAN NORTH AMERICA

The map of late middle and upper Cambrian North America represents an expansion of the area of the epicontinental sea which probably was not at any time actually reached. The middle Cam-



brian sea extended further in certain areas than the upper Cambrian and retreated while the upper Cambrian sea spread over other regions. These details are not well worked out, though in part recognized. The map truly presents, however, the general fact that North America was to a great extent submerged and the land areas very markedly reduced. The prevailingly fine and calcareous sediments of the wide seas and the siliceous coastal plain sediments of the littoral deposits indicate that the relief of the land was low.

The conditions of marine circulation had apparently been modified by the expansion of the interior sea, and the climate conditions incident to widespread seas and low lands had become so ameliorated that similar habitats prevailed throughout a very wide range of latitude.